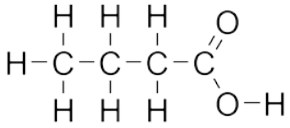
ANSWERS: Reaction mechanisms

1) NaOH or KOH (alcoholic)
Elimination reaction
This is an elimination reaction as a hydrogen atom and a chlorine atom on adjacent carbon atoms are removed, forming a carbon-to-carbon double bond.

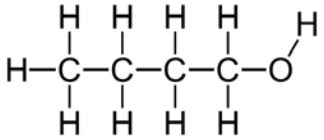
2)

a) Product A:



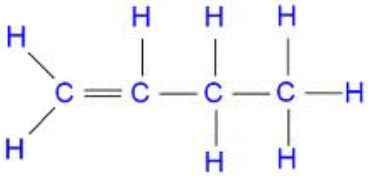
butanoic acid

Product B:



butan-1-ol

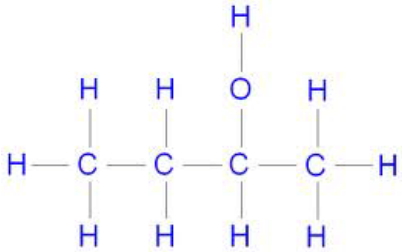
Product C:



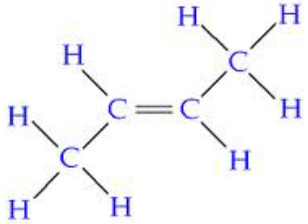
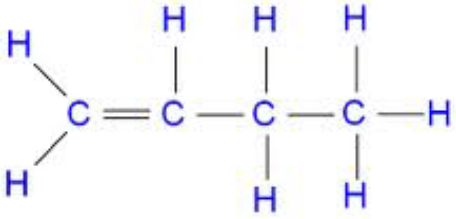
but-1-ene

b) Reactant 1 → no reaction

Reactant 2 →butan-2-ol



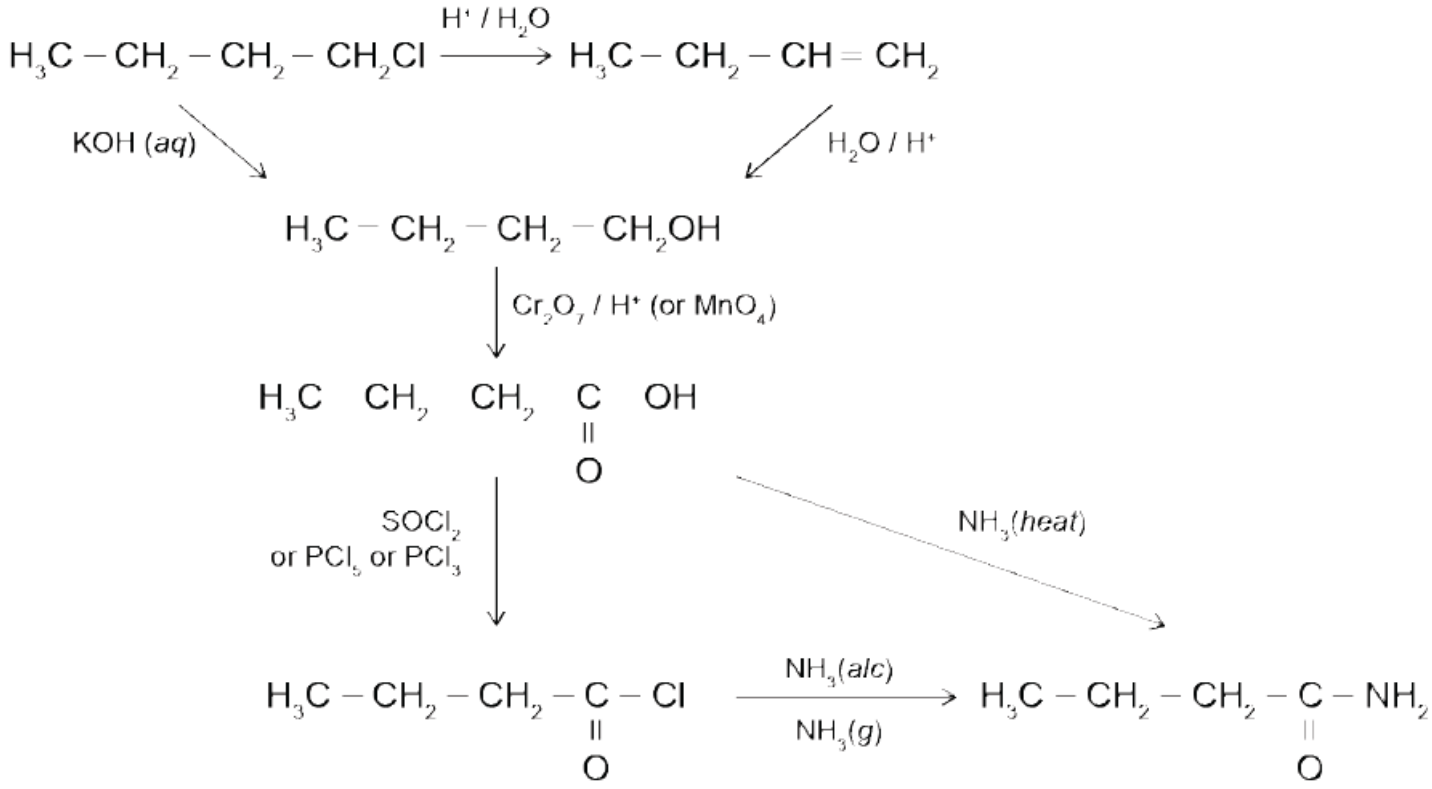
Reactant 3 →

major product	*minor product*
 but-2-ene	 but-1-ene

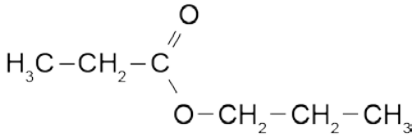
c) The two reaction schemes start with different compounds. The first reaction starts with an aldehyde (butanal) which can be oxidised using $Cr_2O_7^{2-}$ *(reactant 1)* further to a carboxylic acid (butanoic acid). However, the ketone cannot be oxidised as the carbon atom with the double bond to the oxygen atom has no more hydrogen atoms bonded to it so will not be oxidised.
Both butanal/aldehydes and butanone/ketones can be reduced using $NaBH_4$ (Reactant 2) to form alcohols. In the second reaction both the schemes form an alcohol. But the first scheme produces a primary alcohol as that is what an aldehyde is derived from ie a primary alcohol is oxidised to form an aldehyde (butan-1-ol). While in the second scheme a secondary alcohol is produced as the ketone is derived from a secondary (butan-2-ol).

In the last reaction both the schemes from alkenes as conc H_2SO_4 reacts with alcohols to form alkenes. The first scheme forms 1 alkene as the last carbon loses the OH so the double bond can only form with the next carbon so but-1-ene is formed. While in the second scheme because the OH was on the second carbon there are two possible products the major product but-2-ene and the minor product but-1-ene. The major product will form.

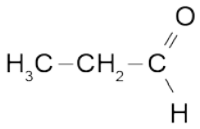
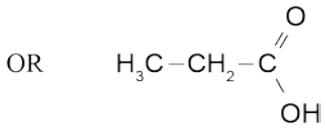
3)



4)

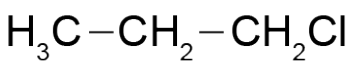
A  propyl propanoate B - sodium propanoate C $H_3C-CH_2-CH_2-OH$ propan-1ol (1-propanol) D  propanoic acid OR propanoyl chloride OR methylpropanoate	Reagent 1 = NaOH(*aq*) Reagent 2 = NaOH(*aq*), accept NaOH(*alc*) if D = acid chloride, Na_2CO_3 (*aq*). Reagent 3 = PCl_5 / $SOCl_2$ / PCl_3. Reagent 4 = $Cr_2O_7^{2-}$ / H^+ or MnO_4^- / (H^+) / Fehling / Benedicts/ Tollens or if D is given as acid chloride, accept PCl_5 / $SOCl_2$ / PCl_3./ methanol or other alcohol + acid to give ester in D.

E

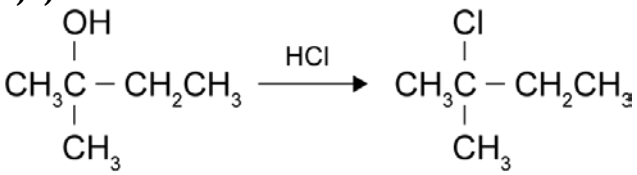



propanal propanoic acid

F

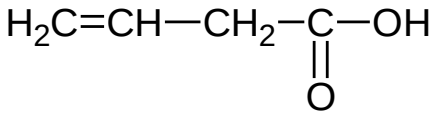


5) i)

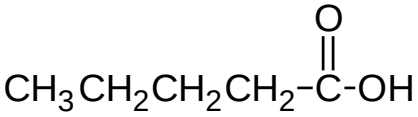


ii) Substitution.
The alcohol group is removed and substituted with the chlorine side chain.

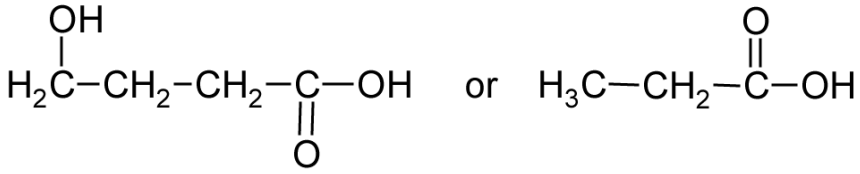
6) i) 4-chlorobutanoic acid



ii) pentanal

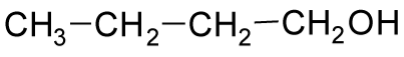


iii) 4-chlorobutanoic acid or propanoyl chloride

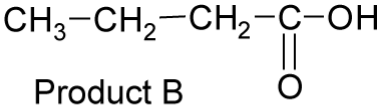


(OR $CH_2OHCH_2CH_2COO^-$ or $CH_3CH_2COO^-$)

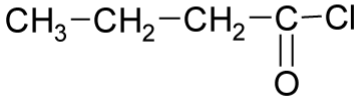
7) Reagent 1 $H^+ / Cr_2O_7^{2-}$ OR MnO_4^- / H^+ OR MnO_4^-
Reagent 2 PCl_3 / PCl_5 / $SOCl_2$ OR HBr OR $SOBr_2$
Reagent 3 PCl_3 / PCl_5 / $SOCl_2$ / conc HCl with $ZnCl_2$ (not just conc HCl)
Reagent 4 NH_3 (alcohol not required)



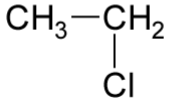
Product A



Product B



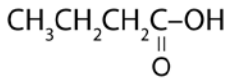
Product C



Product D

Alternative answer:
Reagent 1 (as above) and Reagent 2 = Reagent 1 OR Tollens / Benedicts / Fehlings

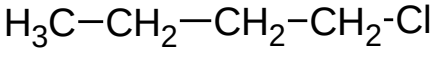
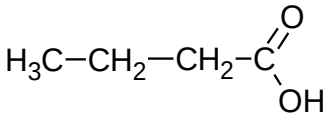
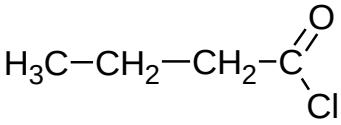
Product B 

Product C 

8) Aldehyde (propanal) is obtained by heating a mixture of propan-1-ol with acidified (potassium dichromate) solution or (acidified) permanganate solution. Propanal can be removed from the solution as it forms, using distillation, as the aldehyde has a lower boiling point than propan-1-ol and the carboxylic acid. Carboxylic acid (propanoic acid) is obtained by reacting a mixture of propan-1-ol with acidified potassium dichromate solution (under reflux conditions) until all of the reactant has been converted to propanoic acid.

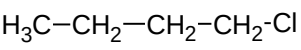
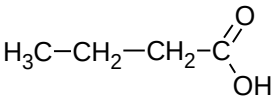
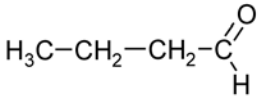
9)

Reagent	**Formula**
1	PCl_3, or PCl_5, or $SOCl_2$, or HCl
2	NH_3
3	$Cr_2O_7^{2-}$ / H^+ or MnO_4^-/H^+
4	PCl_3, or PCl_5, or $SOCl_2$
5	CH_3NH_2

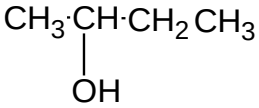
Product	**Name or formula**
1	
2	
3	

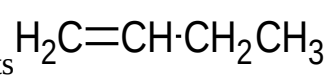
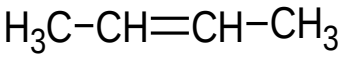
OR

Reagent	**Formula**
1	PCl_3, or PCl_5, or $SOCl_2$, or conc HCl
2	NH_3
3	$Cr_2O_7^{2-}/H^+$ or MnO_4^-/H^+
4	$Cr_2O_7^{2-}$ / H^+ or MnO_4^-/H^+
5	CH_3NH_2

Product	**Name or formula**
1	
2	
3	

10) Substitution
Reagent NaOH (aq)/ NaOH/ OH^- / KOH
Product



Elimination Reagent NaOH (alc), KOH(alc), Ethanolic KOH
Products  
OR
cis-but-2-ene and *trans*-but-2-ene

11) i) $SOCl_2$ / PCl_3 / PCl_5 NOT HCl

ii) $CH_3CH_2CH(NH_2)CH_3$
Accept recognition that substitution will not occur under these conditions alone.

iii) Reagent 1 $Cr_2O_7^{2-}$ / H^+ or MnO_4^- / H^+
Product CH_3COOH
Reagent 2 NaOH, Na_2CO_3, $NaHCO_3$

iv) Reagent 1 conc H_2SO_4
Product $CH_3CH=CH_2$
Reagent 2 Dilute H_2SO_4 or H^+ / H_2O

12)

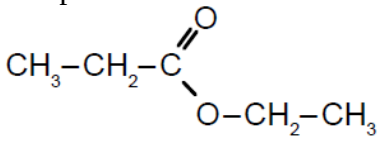
Reaction	Type	Reagent
1	Elimination / Dehydration	conc H_2SO_4
2	Oxidation	$Cr_2O_7^{2-}$ / H^+ or MnO_4^- / H^+
3	Substitution	$SOCl_2$, PCl_3, PCl_5, conc HCl

13)a) i) Reagent 1 – **KOH** in **ethanol**/alcohol

Reagent 2 – NaOH(aq) / NaOH/KOH / KOH (aq) /H2O with OH– – *not H_2O*

Reagent 3 – $SOCl_2$ / PCl_3 / PCl_5 – *not HCl)*

ii) and iii) Compound X (Minor product):
$CH_3CH_2CH_2Br$ or full structure
Name of minor product:
1-bromopropane
CH_3CH_2COCl is propanoyl chloride
Compound Y



OR
CH_3CH_2 $COOCH_2CH_3$ or full structure
Name: ethyl propanoate

b)

(i) Elimination	The molecule HCl / a Cl atom **and** an H atom removed **and** a double bond is created.
(ii) Substitution	Br^- /Br; is removed and replaced / exchanged /swapped with /changed for / substituted with; an OH^-/OH group.
(iii) Oxidation	Oxygen is added / hydrogen is removed / electrons are lost / the number of bonds to oxygen is increased / the oxidation number of carbon increases / $Cr_2O_7^{2-}$ is an oxidising agent / $Cr_2O_7^{2-}$ is reduced to Cr^{3+} so the alcohol is oxidised.

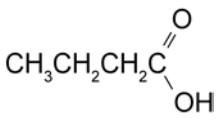
c) If the major product (2-bromopropane) remains in the flask when reagent 2 (NaOH(*aq*)) is added, a substitution reaction would cause the formation of the 2° alcohol propan-2-ol ($CH_3CH(OH)CH_3$) as well as propan-1-ol) This would in turn be oxidised by the dichromate to the ketone/ propanone/ (CH_3COCH_3). No further reaction with reagent 3 or ethanol will occur, so the final mixture would contain a lot of propanone and a smaller amount of the ester.
(If all of the alcohol was not completely oxidised to the ketone, an ester with the ester group attached at the 2nd C atom might form with the propanoic acid and 2-chloropropane might result from excess propan-2-ol reacting with reagent 3.)

14)

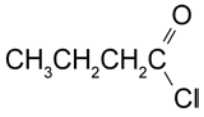
PRODUCTS (letters) REAGENTS (numbers)

1 $Cr_2O_7^{2-}$ / H^+ (or MnO_4^- / H^+)

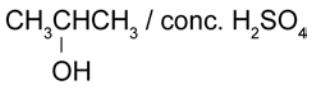
A



B



2



3 conc. H_2SO_4

C $CH_3CH_2CH=CH_2$

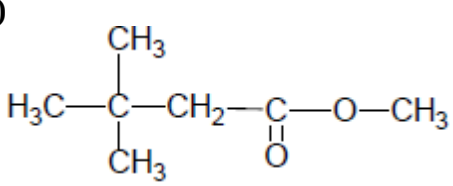
D $CH_3CH_2\underset{\displaystyle Cl}{\underset{|}{C}}H-CH_3$

4 KOH / NaOH

E $CH_3CH_2\underset{\displaystyle OH}{\underset{|}{C}}H-CH_3$

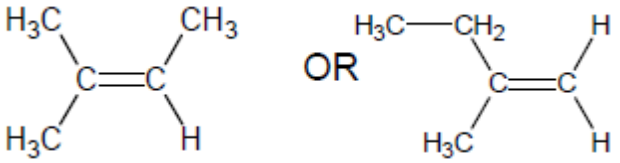
5 $Cr_2O_7^{2-}$ / H^+ (or MnO_4^- / H^+)

15) i)



condensation /esterification/substitution

ii)



elimination